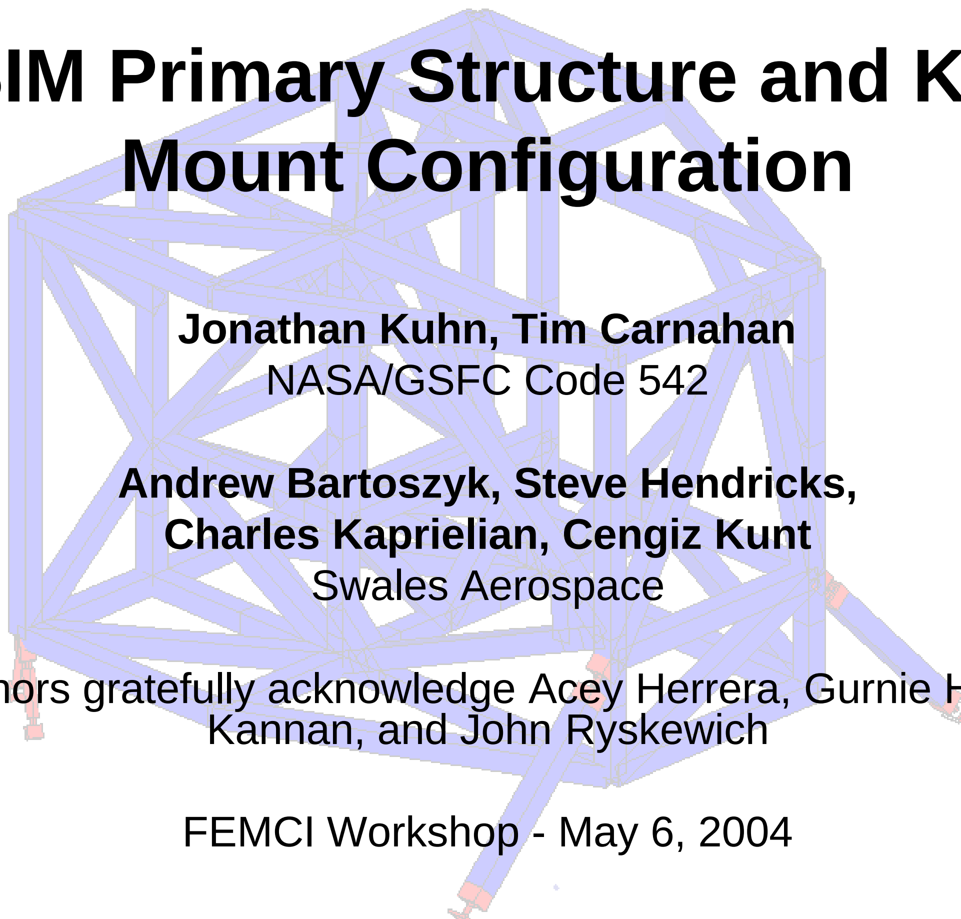
JWST ISIM Primary Structure and Kinematic Mount Configuration



Jonathan Kuhn, Tim Carnahan
NASA/GSFC Code 542

Andrew Bartoszyk, Steve Hendricks,
Charles Kaprielian, Cengiz Kunt
Swales Aerospace

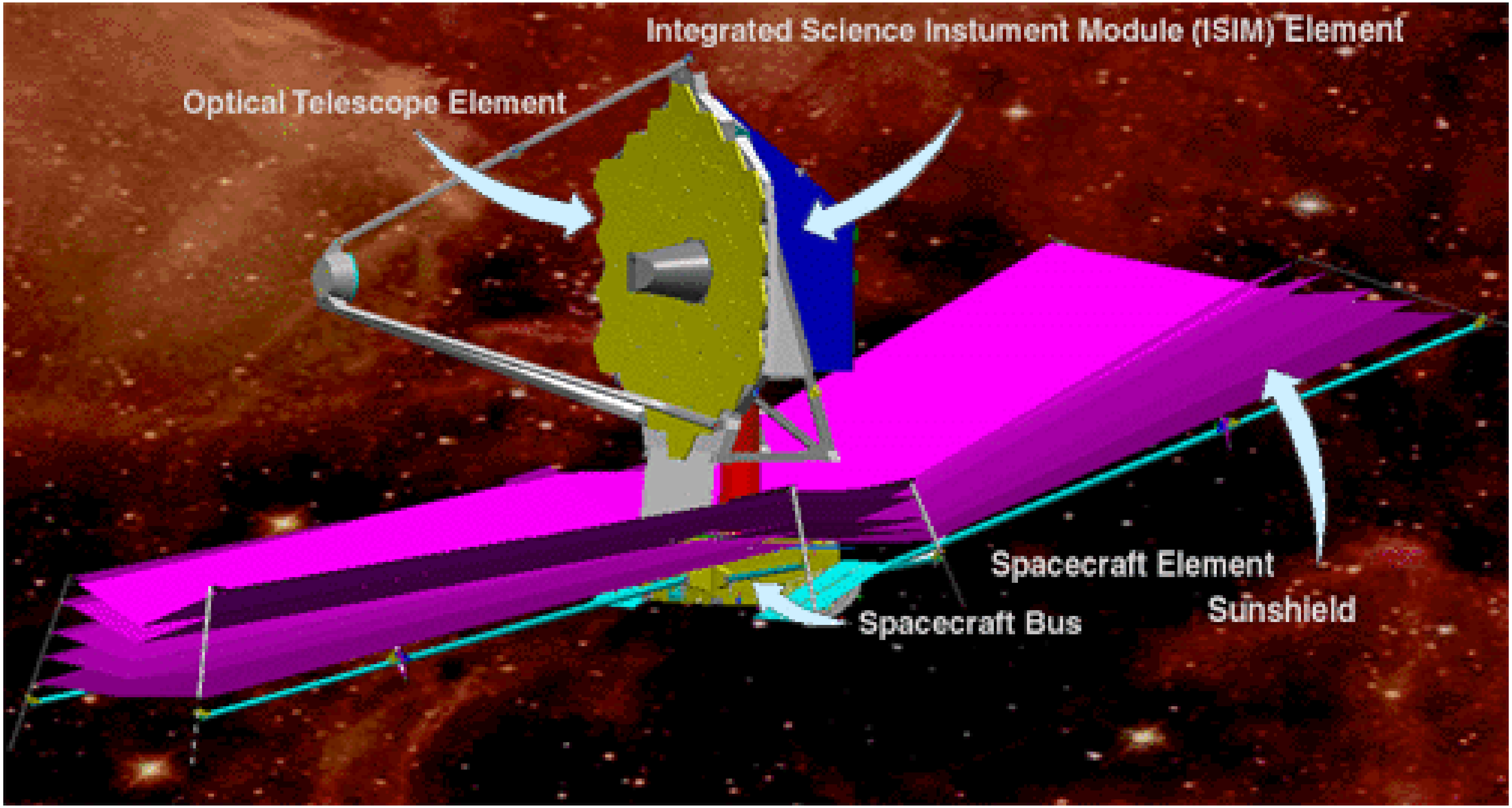
The authors gratefully acknowledge Acey Herrera, Gurnie Hobbs, K. Kannan, and John Ryskewich

FEMCI Workshop - May 6, 2004

Outline

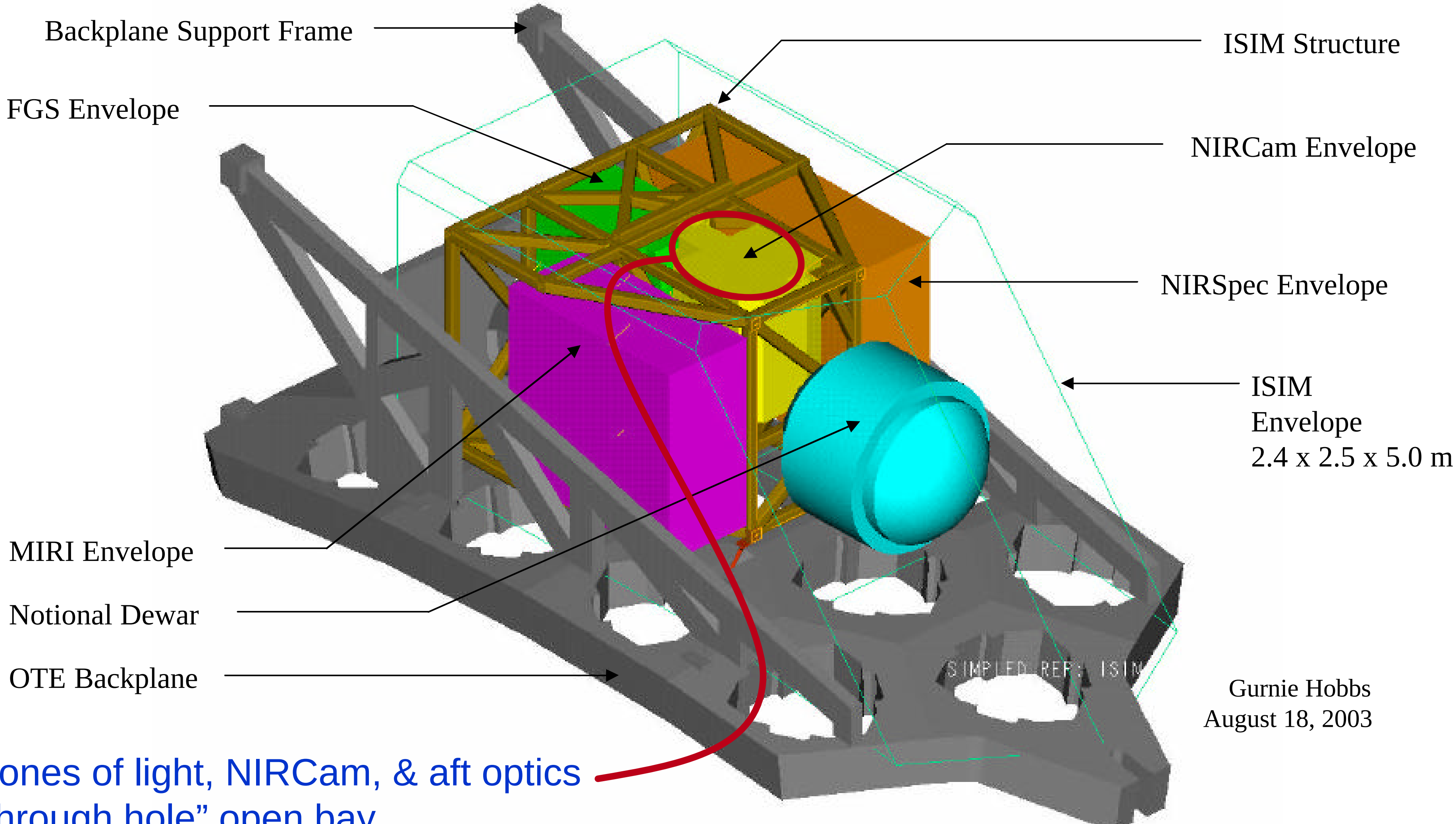
- Introduction
  - JWST, ISIM, & ISIM Requirements
- Structural Evolution
- Current Concept
  - Tube topology, mode shapes, & kinematic mounts configuration
- MSC/NASTRAN Optimization
- Conclusion

JWST
James Webb Space Telescope



Courtesy of John Nella, et al. Northrop Grumman Space Technology

ISIM
Integrated Science Instrument Module



Gurnie Hobbs
August 18, 2003

Cones of light, NIRCam, & aft optics “through hole” open bay

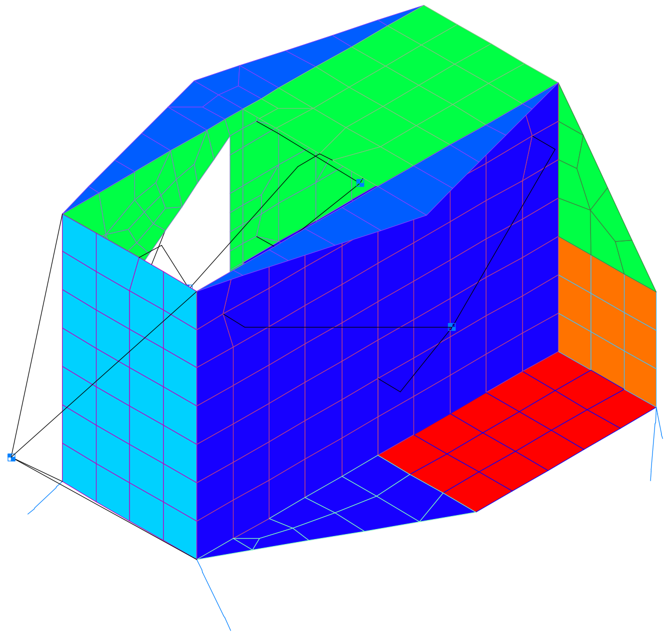
ISIM Structure Requirements

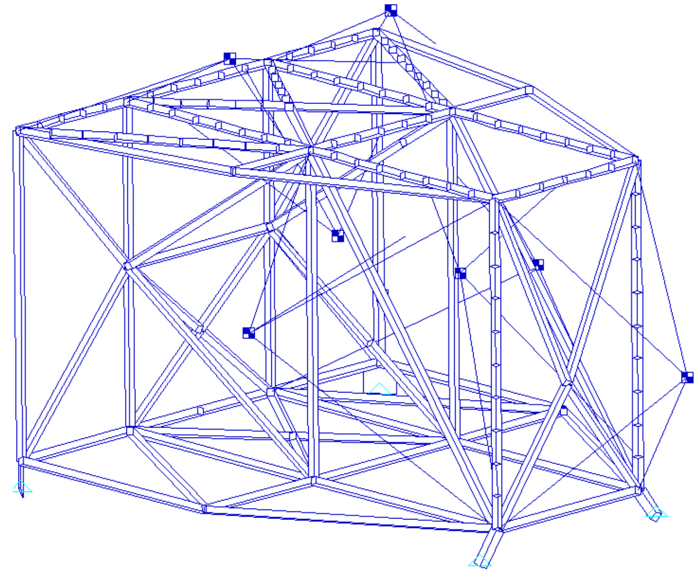
- Driving requirements:
  - Instrument interfaces, access, & volume
  - Mass:
    - Total: 1400 kg
    - Structure: 300 kg (~21%)
  - Fixed base first mode frequency = 25 Hz
    - 35 Hz w rigid SI's & Joints
  - Nominal operating temperature: 32 K at BOL
  - On-orbit temperature shift: ~0.5 K
  - Instrument on-orbit stability (~200 nm, 120 milli-arc-seconds)
- Challenges:
  - Mass/stiffness/interface balance
  - Complex all-composite joints
  - Metal/composite joint survivability
  - On-orbit stability of heterogeneous structure

Goal: No removable structure

Structure Evolution

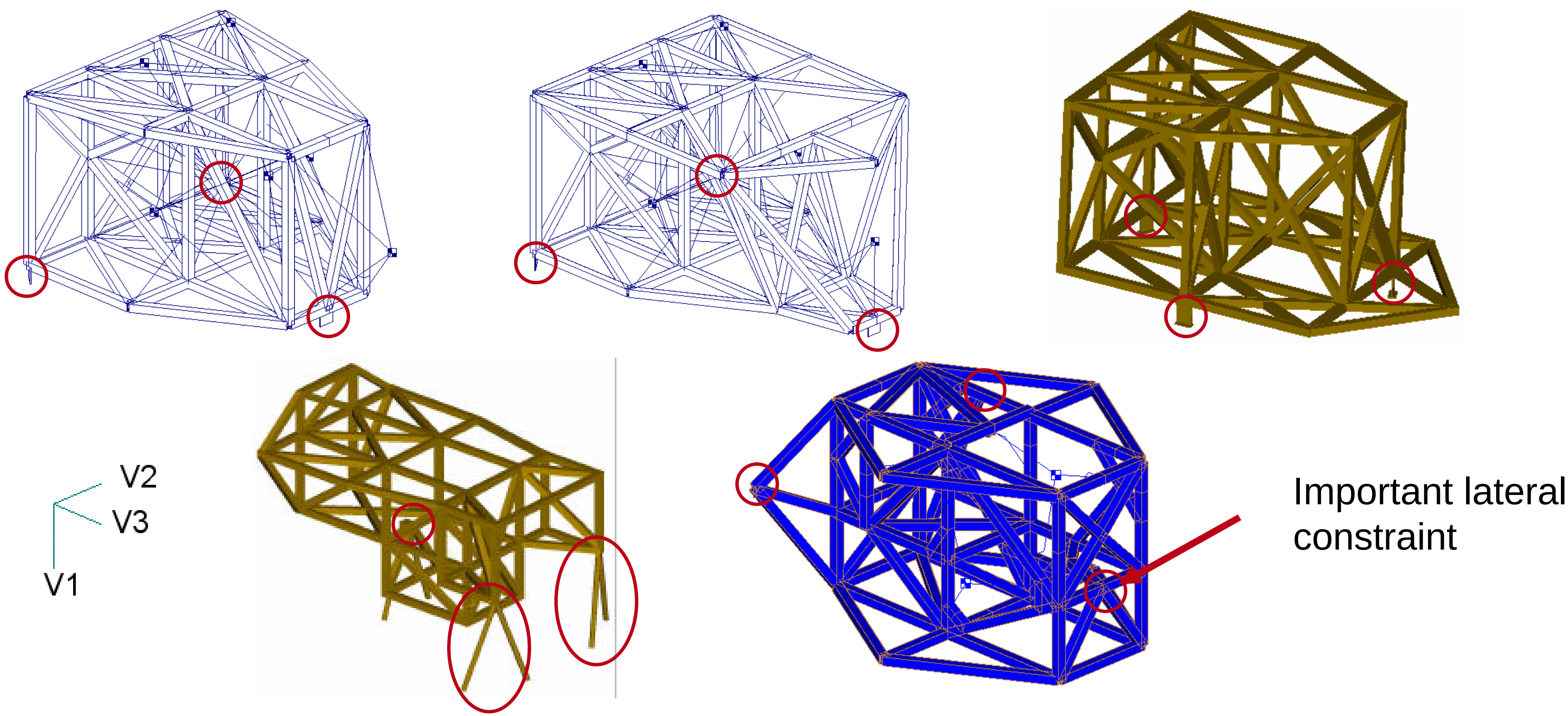
- Material: Considered Composite, Aluminum, Beryllium, AlBeMet
  - Composite selected for dimensional stability and specific stiffness
- Construction: Considered Frame vs. Panel
  - Unoptimized frame with tube axial modulus of 30 Msi weighs ~160 kg
  - Optimized panel with quasi-isotropic facesheet modulus of 17 Msi weighs ~225 kg





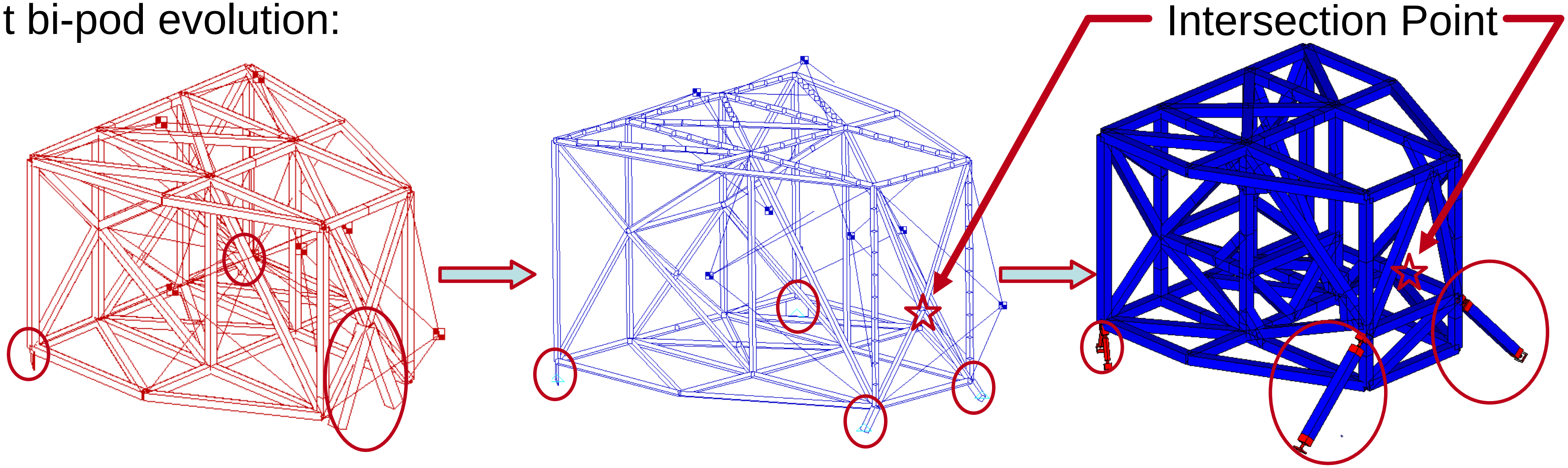
Structure Evolution

- ISIM/OTE interface configuration is critical to ISIM frequency & mass
- Started with 3 point interface, considered many options
- Found that a lateral constraint near projected CG on +V3 end is important due to the through hole open bay

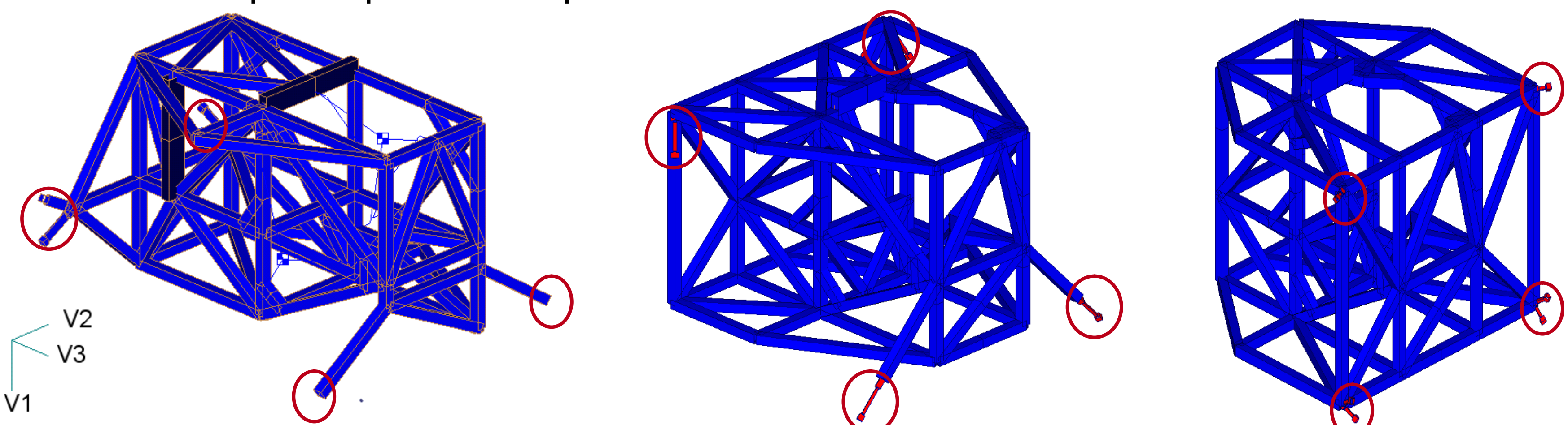


Structure Evolution

Split bi-pod evolution:



Some other split bi-pod concepts:

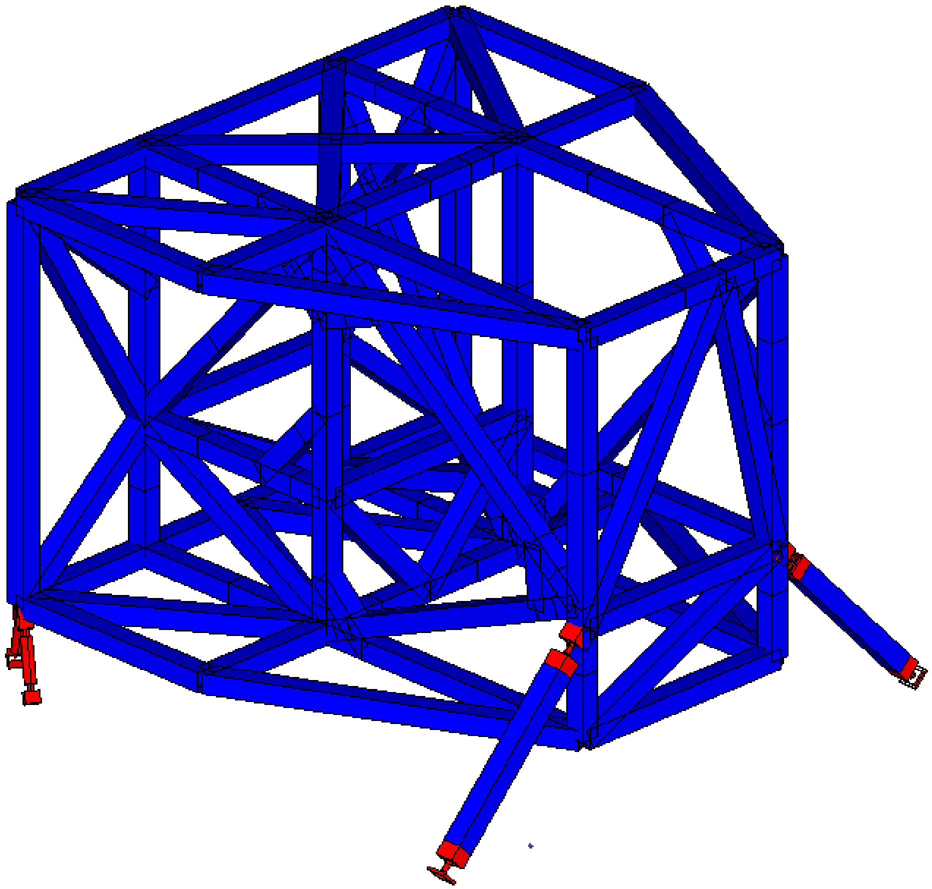


Current Concept

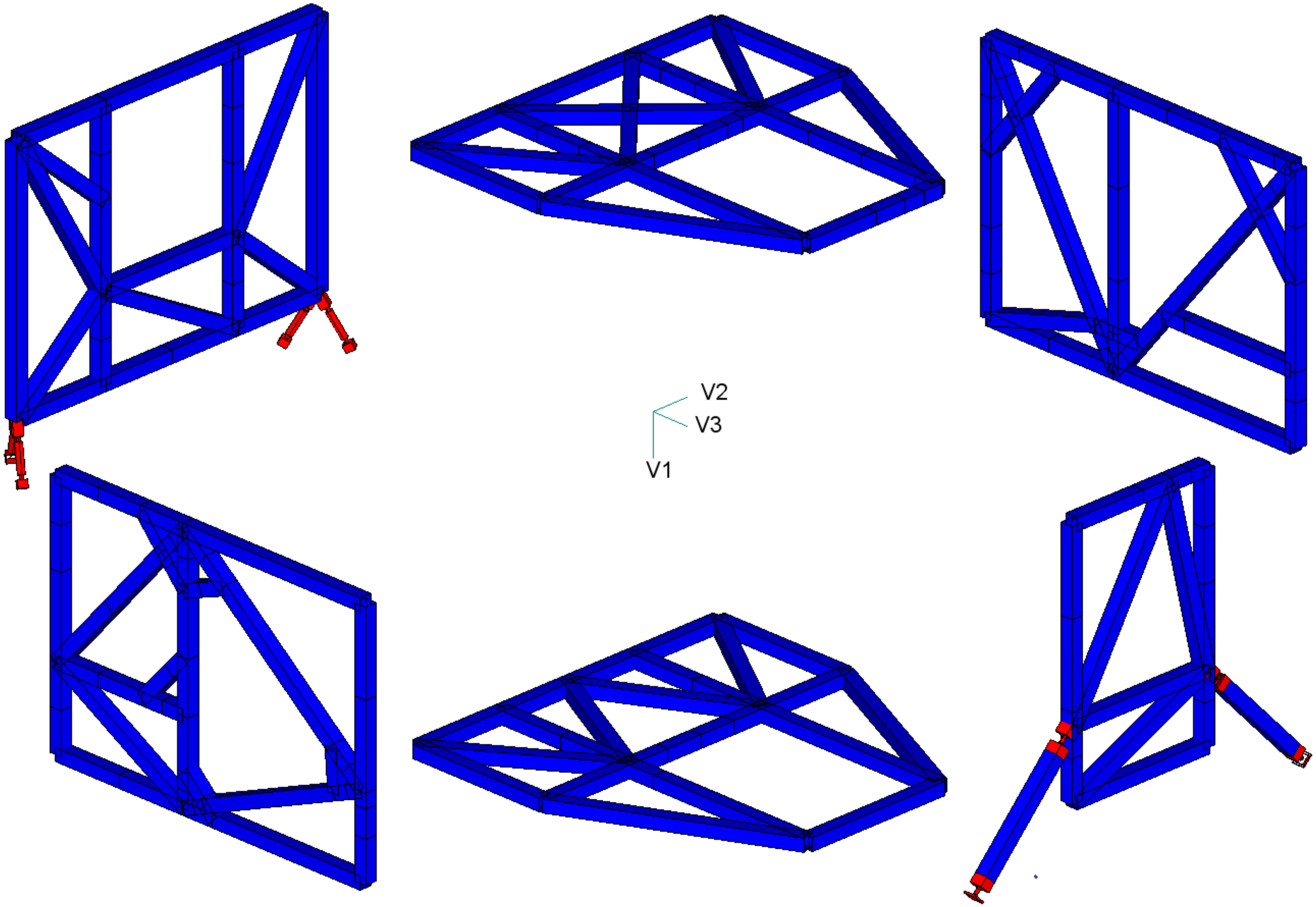
- Frequency: 32.3 Hz
  - rigid joints & 50 Hz instruments

- Tube mass: 160 Kg
- Tube length: 78.5 m
- Tube section: 75 x 75 mm
- Tube wall thickness: 4.6 mm

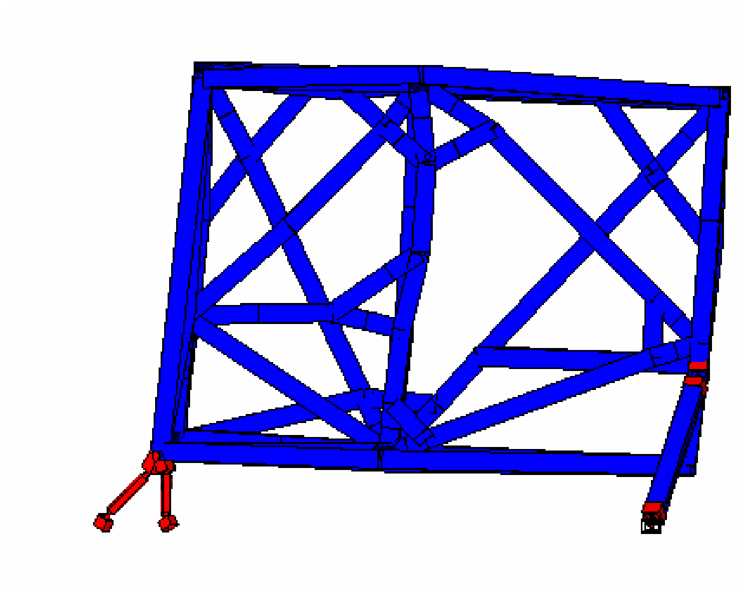
- Number of joints: 59
  - Including SI landing pads



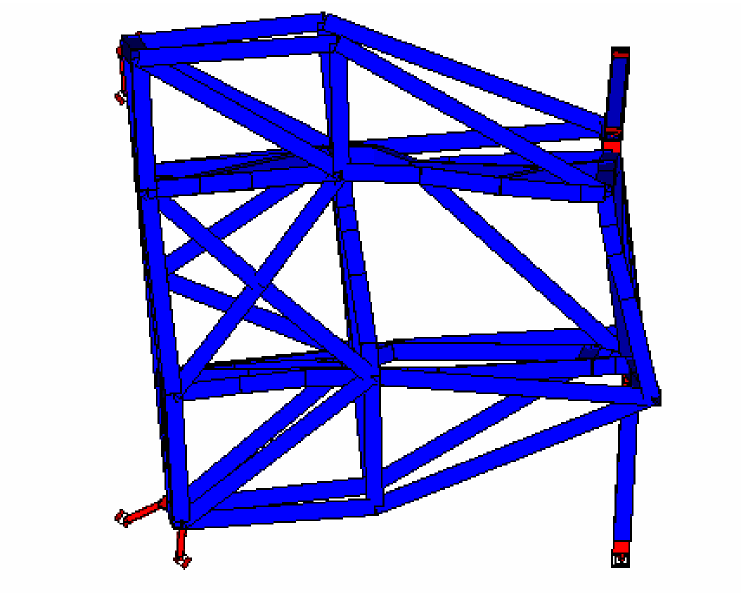
Current Concept



Mode Shapes



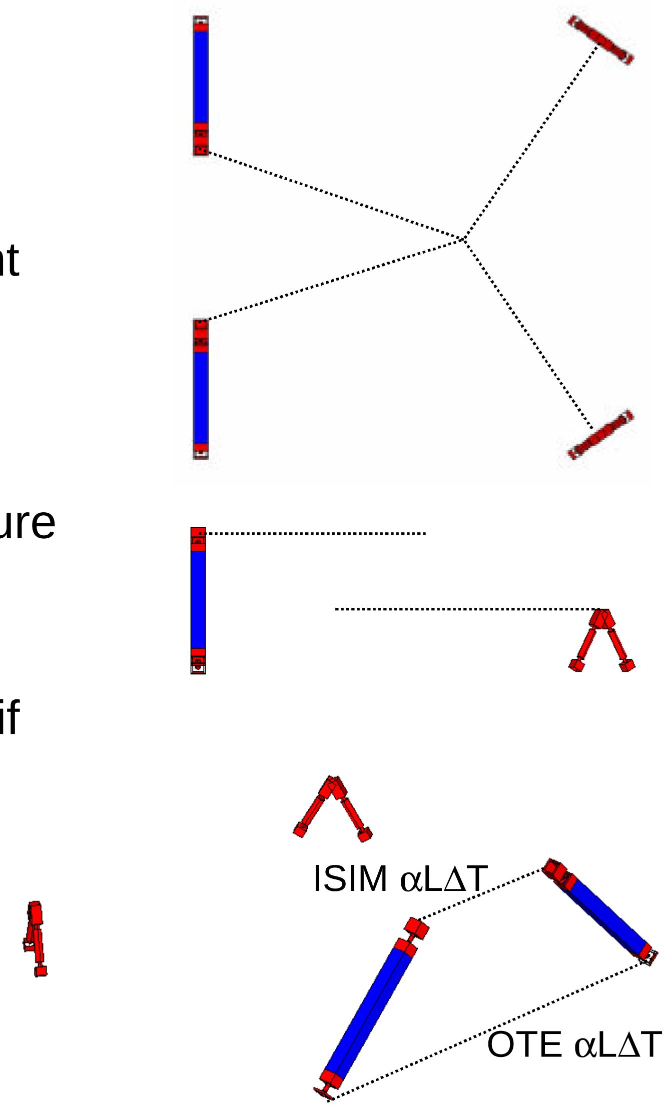
Mode 1: 32.3 Hz



Mode 2: 36.3 Hz

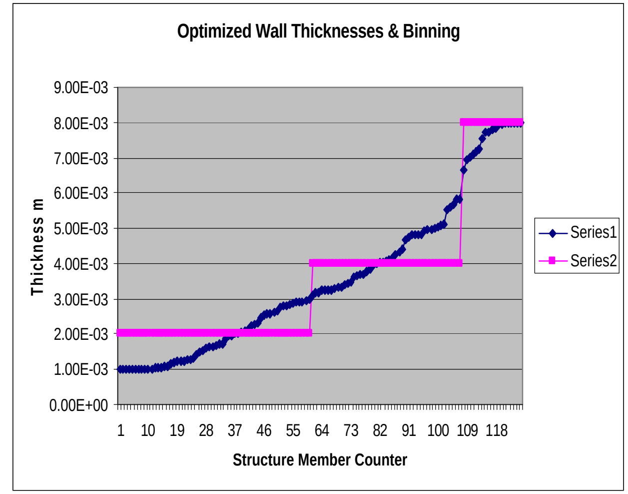
Kinematic Mount Configuration

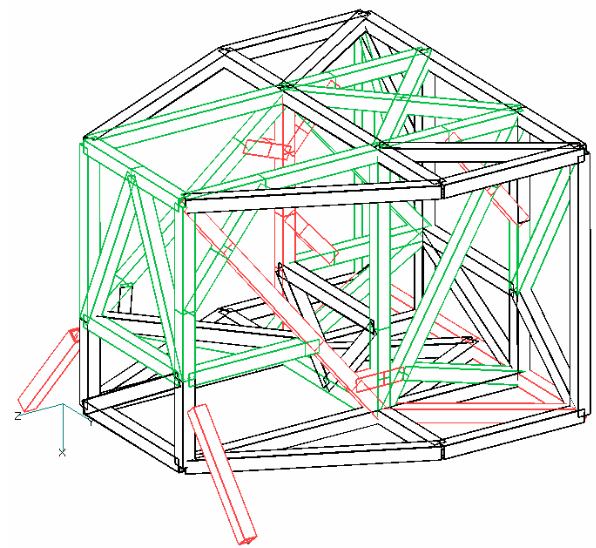
- 6 monopod constraints
  - 2 sets of bipods
  - 1 “split bipod”
- Idealized/pinned mounts are statically determinant
- Rigid rotation on bulk cooldown due to:
  - Line of action mismatch
  - ISIM/OTE differential strain
- Rigid rotation plus over constrained torsional flexure stiffness results in secondary axial loads
- Rigid rotation currently within requirements
- May tune monopod design to counteract rotation if needed



MSC/NASTRAN Optimization

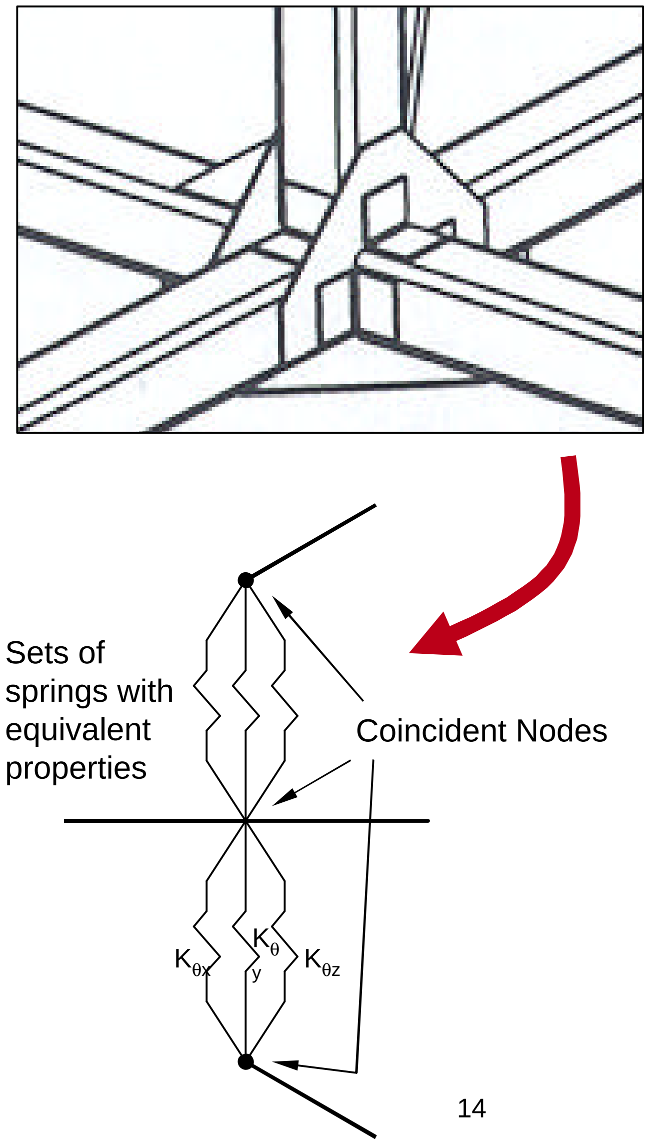
- Panel concept
  - Iterate between:
    - Manual panel layout
    - Facesheet thickness optimization using NASTRAN optimizer
- Tube wall thickness
  - Discrete optimization did not work well for this application – slow convergence and impractical results
  - Tube wall thickness optimization in specified range using NASTRAN optimizer
  - Manually group wall thicknesses into “bins”
  - Developed a perl script to automate the process

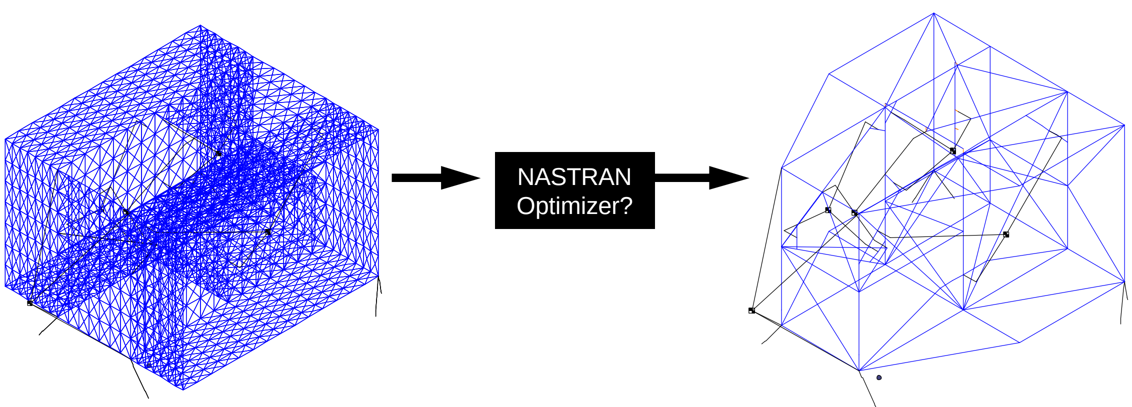




MSC/NASTRAN Optimization Applications

- Joint effective stiffness
  - Used NASTRAN optimizer to tune springs in effective joint models
- Primary structure topology
  - Attempted “topology” optimization by using a fine mesh and letting stiffness go to zero
  - Need ability to turn elements on/off during optimization to be effective





ISIM Structural Analysis Status & On-Going Work

- Completed an extensive set of configuration, trade, and optimization studies to arrive at a baseline for the ISIM Structure and its Kinematic Mounts to the OTE.
- The resulting ISIM Structure and Kinematic Mounts meet the overall requirements of weight, stiffness, OTE interface, instrument accommodations and access, and manufacturability, which are both challenging and conflicting.
- A more detailed analysis of the baseline ISIM structure is now in progress in support of bringing the structure design to PDR level by addressing all the critical requirements in detail including stiffness, strength, distortion, manufacturability, and assembly.